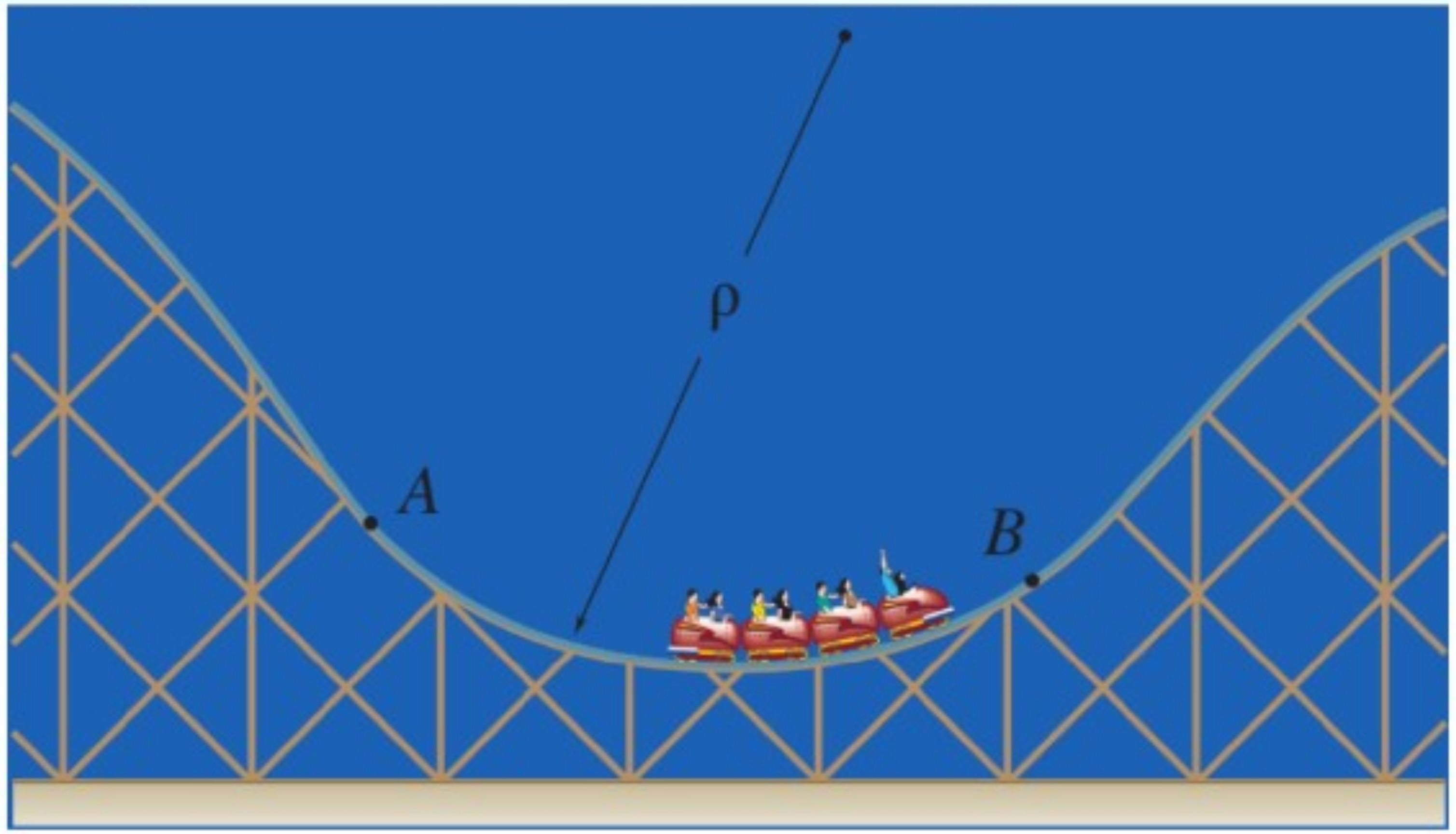
Determine the maximum speed that the cars of the roller coaster can reach along the circular portion AB of the track if $\rho = 25$ m and the normal component of their acceleration cannot exceed $3g$.



$$\vec{a} = \frac{d\vec{v}}{dx} e_t + \frac{v^2}{\rho} e_n$$

$$a = \frac{v^2}{\rho}$$

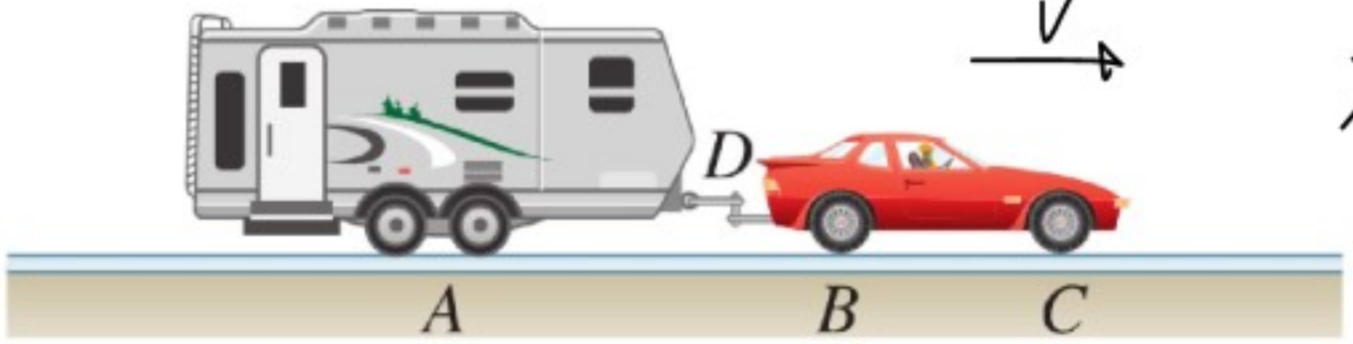
$$3g = \frac{v^2}{\rho}$$

$$v = \sqrt{3g\rho}$$

$$= \sqrt{3 \cdot 9.8 \cdot 25} = \boxed{27\ m/s}$$

A 1200-kg trailer is hitched to a 1400-kg car. The car and trailer are traveling at 72 km/h when the driver applies the brakes on both the car and the trailer. Knowing that the braking forces exerted on the car and the trailer are 5000 N and 4000 N, respectively, determine (*a*) the distance traveled by the car and trailer before they come to a stop, (*b*) the horizontal component of the force exerted by the trailer hitch on the car.

V



$$T_1 + U_{1\to2} = \cancel{T_2}^{\,0}$$

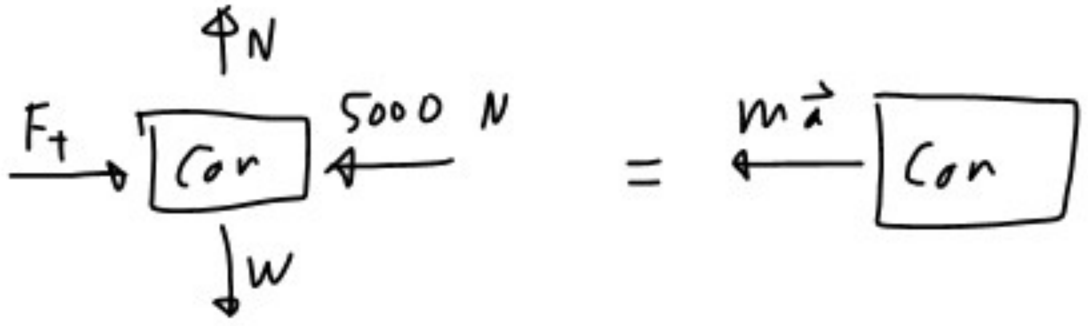
$$72 \text{ km/h}\left(\frac{1\text{ h}}{3600\text{ s}}\right)\left(\frac{1000\text{ m}}{1\text{ km}}\right) = 20 \text{ m/s}$$

$$\frac{1}{2}mv^2 + Fd = 0$$

$$\frac{1}{2}mv^2 = -Fd$$

$$\frac{mv^2}{-2F} = d$$

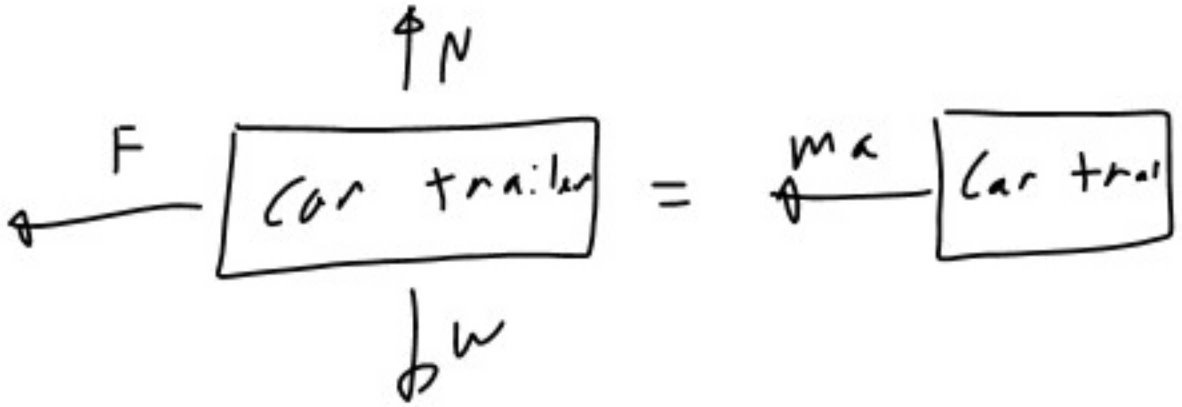
$$\frac{(1200+1400)20^2}{2(5000+4000)} = \boxed{57.8 \text{ m}}$$



$$F_t - 5000 = -ma$$

$$F_t - 5000 = -1400(3.46)$$

$$F_t = 5000 - 1400(3.46) = \boxed{159\ N}$$

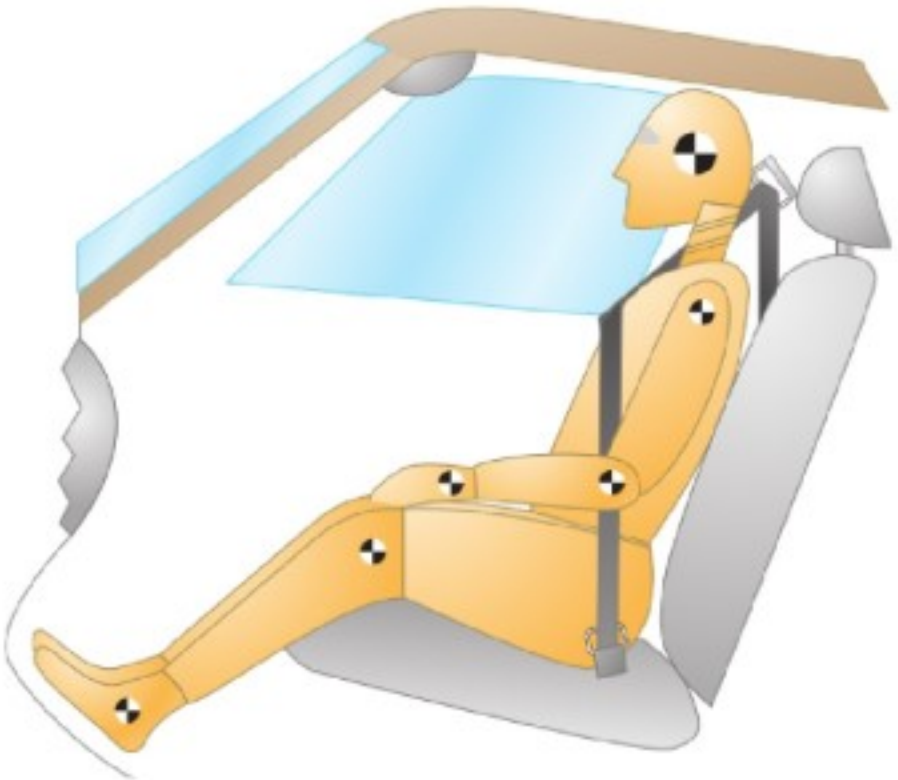


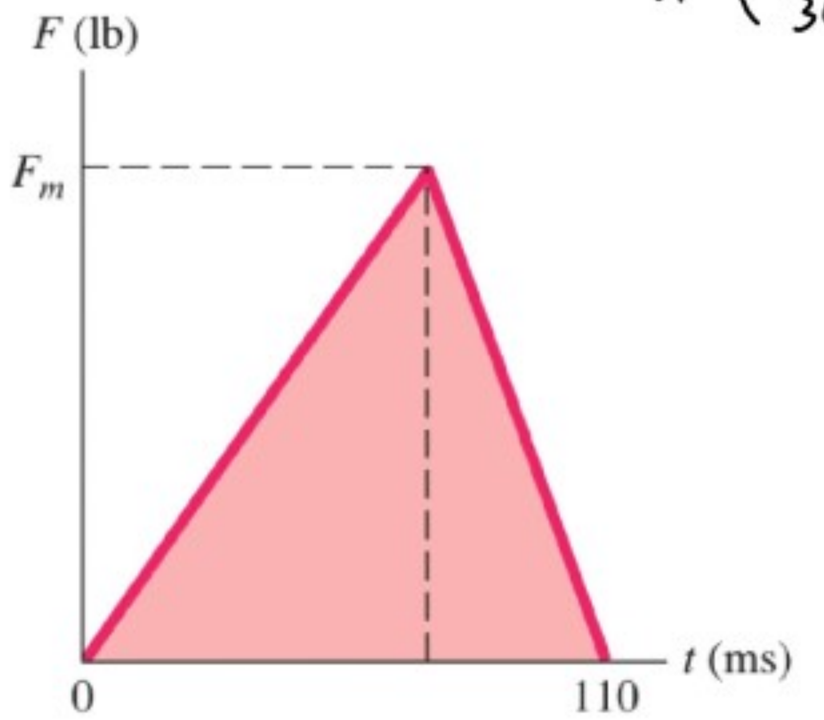
$$F = ma$$

$$a = \frac{F}{m} = \frac{4000 + 5000}{1200 + 1500} = 3.46\ m/s^2$$

An estimate of the expected load on over-the-shoulder seat belts is to be made before designing prototype belts that will be evaluated in automobile crash tests. Assuming that an automobile traveling at 45 mi/h is brought to a stop in 110 ms, determine (*a*) the average impulsive force exerted by a 200-lb man on the belt, (*b*) the maximum force F_m exerted on the belt if the force–time diagram has the shape shown.

$$45\ \frac{mi}{h}\left(\frac{1\ h}{3600\ s}\right)\left(\frac{5280\ ft}{1\ mi}\right) = 66\ ft/s$$





$$\vec{L}_1 + \overrightarrow{Imp}_{1\to 2} = \cancel{\vec{L}_2}^{\,0}$$

$$mV + F_{avg}\,\Delta t = 0$$

$$\frac{200}{32.2}66 + F_{avg}\;0.11 = 0$$

$$\frac{200}{32.2}66 = -0.11F_{avg}$$

$$\frac{200\cdot 66}{-0.11\cdot 32.2} = \boxed{-3727\text{ lb}}$$

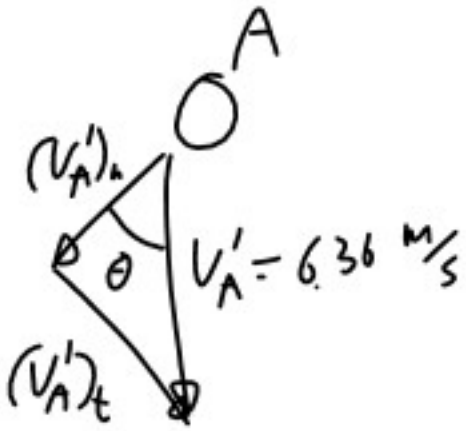
$$\overrightarrow{Imp}_{1\to 2} = F_{avg}\,\Delta t = \int_{t_1}^{t_1} F\,dt = \frac{1}{2}F_m\,\Delta t$$

$$F_{avg}\,\cancel{\Delta t} = \frac{1}{2}F_m\,\cancel{\Delta t}$$

$$2F_{avg} = F_m$$

$$2(-3727) = \boxed{F_m = -7453\text{ lb}}$$

A 600-g ball A is moving with a velocity of magnitude 6 m/s when it is hit as shown by a 1-kg ball B that has a velocity of magnitude 4 m/s. Knowing that the coefficient of restitution is 0.8 and assuming no friction, determine the velocity of each ball after impact.

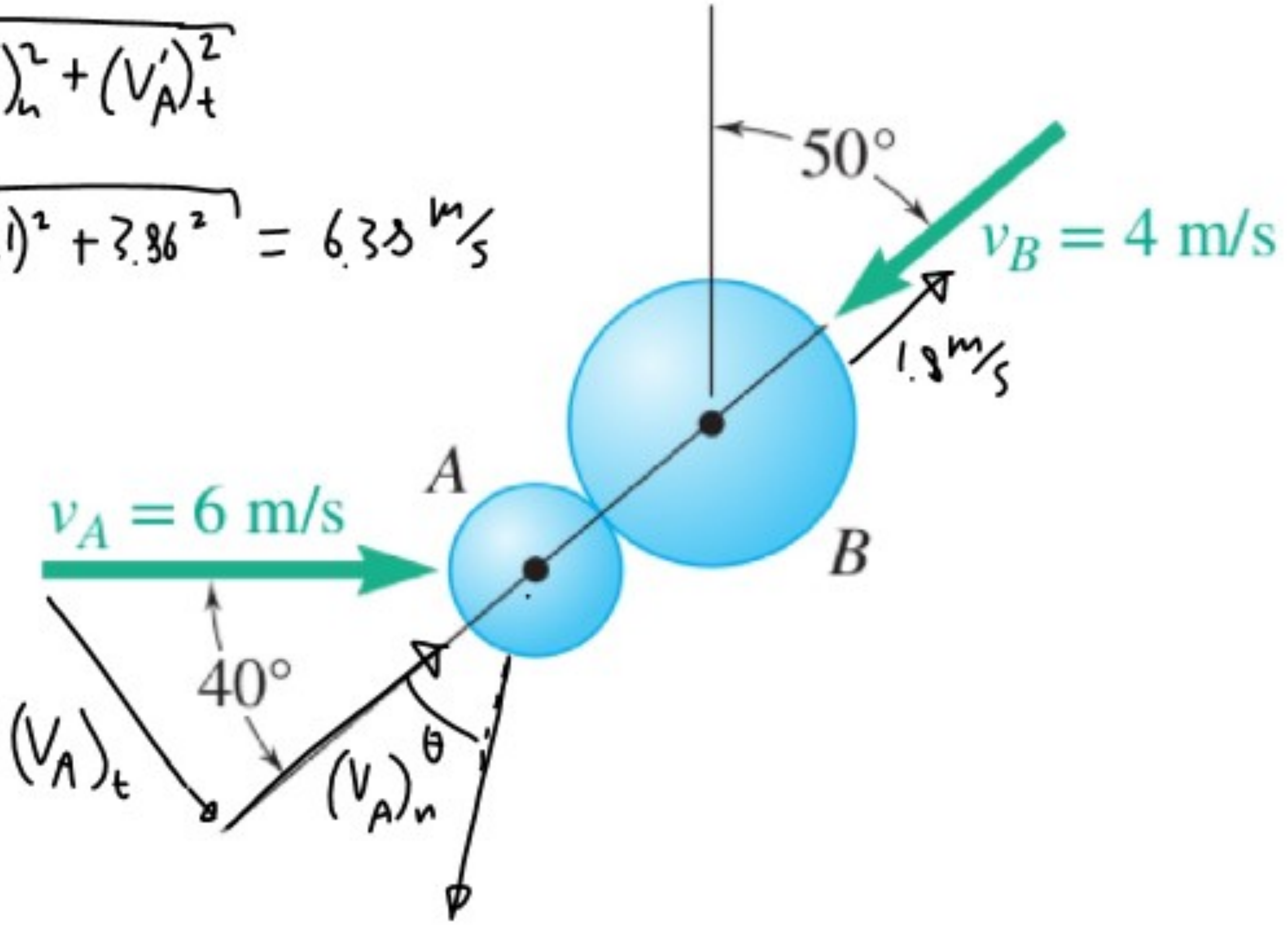


$$V'_A = \sqrt{(V'_A)_n^2 + (V'_A)_t^2}$$

$$= \sqrt{(-5.1)^2 + 3.86^2} = 6.38 \text{ m/s}$$

$$\sin\theta = \frac{(V'_A)_t}{V'_A} = \frac{3.86}{6.36}$$

$$\theta = 37.3^\circ$$



$$(V_A)_n = 6\cos 40 = 4.6 \text{ m/s}$$

$$(V'_A)_t = (V_A)_t = 6\sin 40 = 3.86 \text{ m/s}$$

$$(V_B)_n = -4 \text{ m/s}$$

$$(V'_B)_t = (V_B)_t = 0$$

$$(V_A')_n - (V_B')_n = e\left((V_B)_n - (V_A)_n\right)$$

$$= 0.8(-4 - 4.6)$$

$$(V_A')_n - (V_B')_n = -6.88$$

$$(V_A')_n = (V_B')_n - 6.88$$

$$= 1.8 - 6.88 = -5.1$$

$$m_A(V_A')_n + m_B(V_B')_n = m_A(V_A)_n + m_B(V_B)_n$$

$$0.6\,(V_A')_n + 1\,(V_B')_n = 0.6 \cdot 4.6 - 4$$

$$0.6(V_A')_n + (V_B')_n = -1.24$$

$$0.6\left((V_B')_n - 6.88\right) + (V_B')_n = -1.24$$

$$0.6\,(V_B')_n - 4.13 + (V_B')_n = -1.24$$

$$(0.6 + 1)(V_B')_n = 2.89$$

$$(V_B')_n = \frac{2.89}{0.6+1} = \frac{2.89}{1.6} = 1.8 \text{ m/s}$$